Semi-Annual Review of the Monitoring Data for the Boise Front Geothermal System, January – June, 2003

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1. DOWNTOWN BOISE AND HARRIS RANCH

1.1. Production

In the first six months of 2003, the four downtown district heating systems extracted 386 million gallons, and re-injected 254 million gallons (66%). This amount is estimated to be eight million gallons (two percent) more than the first six months of 2002. Volumetric calculations for the Boise Warm Springs Water District (BWSWD) wells are based on data from the Sparling meter in 2003 because they are similar to the Signet meter readings in 2000 and 2001. Missing data in 2000 – 2002, and a difference of 12 million gallons between the Sparling and Signet meters in 2003 make it difficult to accurately determine the production amount at BWSWD.

1.2. BLM Water Levels

The BLM well is located on the U. S. Geological Survey (USGS) property; data are collected by the USGS. Water levels in the BLM well have risen steadily since early 1999 (Figure 1). The "trough" value (i.e., the low value which occurs between late January and early March each year) has increased almost 25 feet in the last 5 years. The "peak" value (i.e., the maximum value which occurs in late September to early October each year) has increased at least 15 feet in the last 5 years. However, the "peak" values for the last three years are either: 1) unusual, as in 2001 when the BLM well flowed causing a high spike, 2) missing as in 2002, or 3) not yet recorded as in 2003.

1.3. Data Summaries by Water System

1.3.1. Boise Warm Springs Water District West, East, and #3

Monitoring data for BWSWD West, East, and #3 were submitted in hardcopy by Rod Baldwin. Log sheets contain one entry per day for flow, water levels, temperature, and other data. Flow and total volume are measured using Signet flow meters on the East and West wells, and a Sparling meter that recorded a combined flow from the two wells. Boise Warm Springs Water District also provided monthly production summaries to IDWR. Table 1 shows 2003 data for January through June in comparison with the same time periods for 2000, 2001, and 2002.

Table 1. Production at BWSWD for January through June, 2000-2003.

Year	Signet Meter	Sparling Meter
2000	119 million	Incomplete
2001	117 million	Incomplete
2002	Incomplete	No data
2003	131 million	119 million

It is difficult to determine the mostly likely production total for this time period because data are missing for several of the years.

Water levels in the West well were markedly different in late 2002 and early 2003 than they were in previous years. The low reading was almost 50 feet higher in February 2003 than in February 2002 (Figure 2). The east well, which is the main producing well, actually had a slightly lower "trough" value in 2003 than in 2002.

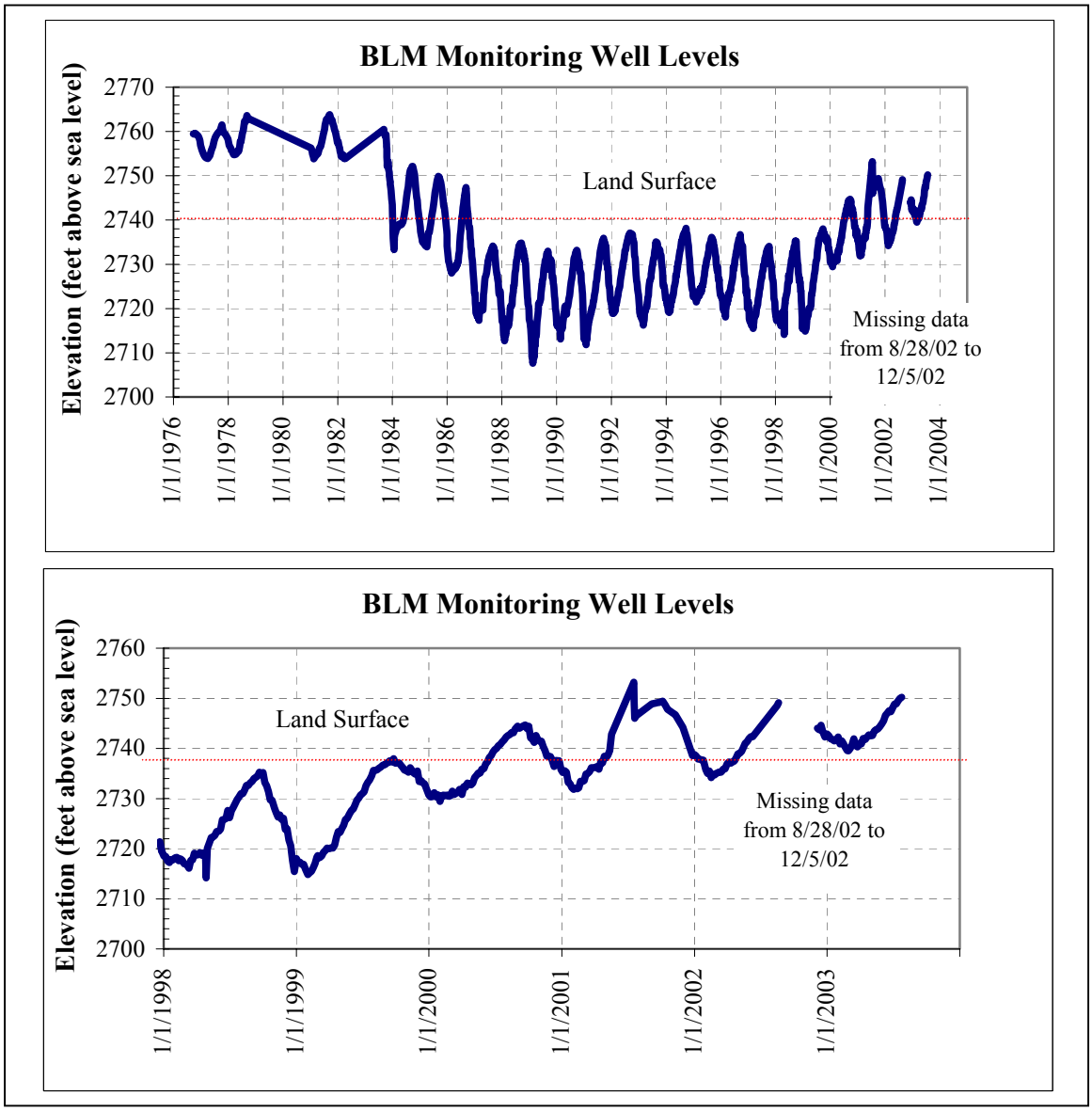

Figure 1. Water levels in the BLM Monitoring well.

1.3.2. State of Idaho Capitol Mall Production and Injection wells

Monitoring data for the Capitol Mall system were submitted in Dbase® files by Bill Hudson. The data files contain one reading for every two-hour interval, which was recorded by a computerized data logging system. Files containing discharge data were imported into Excel®, and monthly production summaries were calculated. Production for January through June was about 77 million gallons. In 2002, production was about 73 million gallons during this time period, but this figure is based on some estimates for May and June because of missing data. Water temperatures, system pressure readings, and other data were also submitted on Dbase® files.

Maximum daily water supply temperatures rose slightly from 1994 through 1998, and then dropped about 1.5 degrees Fahrenheit from 1998 to 2003 based on a visual inspection of the data (Figure 3).

Maximum monthly temperature readings from January 1991 through June 2003 were determined and then transformed to remove seasonal effects[1]. The Spearman rho test was used in order to calculate a Pearson product moment correlation coefficient. The resulting coefficient[2] was –0.33, which indicates that there was a significant decreasing trend in the de-seasonalized monthly maximum water temperatures from 1991 through June 2003 at the 95 percent confidence level. The Spearman test yielded a coefficient of –0.8 for the data from 1997 through June 2003, which is the portion of the graph with the steepest decline since the mid 1980s.

1.3.3. City of Boise – BGL #1, #2, #3, and #4, Injection, Kanta, and Quarry View Park wells

Production, injection, and other data for the City wells were submitted in an Excel® spreadsheet and handwritten data sheets by Kent Johnson. The frequency of the data on the production spreadsheet was approximately once-a-week. The City also records the amount of water discharged to the Boise River on a weekly basis.

The City supplied data for their Injection well in an Excel® file, which included flow, pressure, and temperature data. The data were recorded on an hourly basis. Injection flow, temperatures, and pressures graphs showed regular cycles since mid-1999. The injection rates and operating pressures had longer durations of high values in the first half of 2003 than in the previous two years (Figure 4). The injection temperatures in late May, 2003 were unusually high.

The City's total production as calculated from the BGL #2 and #4 wells was about 104 million gallons for the first half of 2003, which was nearly identical to the amount during this time interval in 2002. About 90.5 million gallons (87 percent) were re-injected.

Wellhead pressure and water temperature data were submitted for the BGL #1 well in an Excel® file. Data are recorded six times a day by a computerized data recorder. Water pressure dropped about five pounds from late September, 2002, to late February, 2003 (Figure 5).

Manually-recorded shut-in pressures for the BGL #1, #2, and #4, and water levels for the BGL #3 were submitted in hardcopy. Slightly less than one year of data is available for these four wells (Figure 5). According to Table 2 of Exhibit 1 of the Order signed in July, 2002, the City is to collect weekly data at the BGL #2, #3, and #4 wells during the time periods from February 1 through March 14, and from September 1 through October 12. This would equate to 18 readings total for the three wells during each of these two time periods. However, only six readings were taken during the February-March six week time period (four in the #2, one in the #3, and one in the #4).

[1]The average value for each month was calculated (For example, the January values for 1991 through 2003 had an average of 154.84 degrees Fahrenheit). Adjusted monthly values were calculated by subtracting the average monthly value from the individual monthly values (For example, the January average of 154.84 was subtracted from the January, 1991, average of 155.0 degrees Fahrenheit, and so forth for all of the January readings). An overall average for all of the data was calculated and added to each adjusted monthly value.

[2]Correlation coefficients range from – 1 to 1 with zero indicating no trend between the two variables.

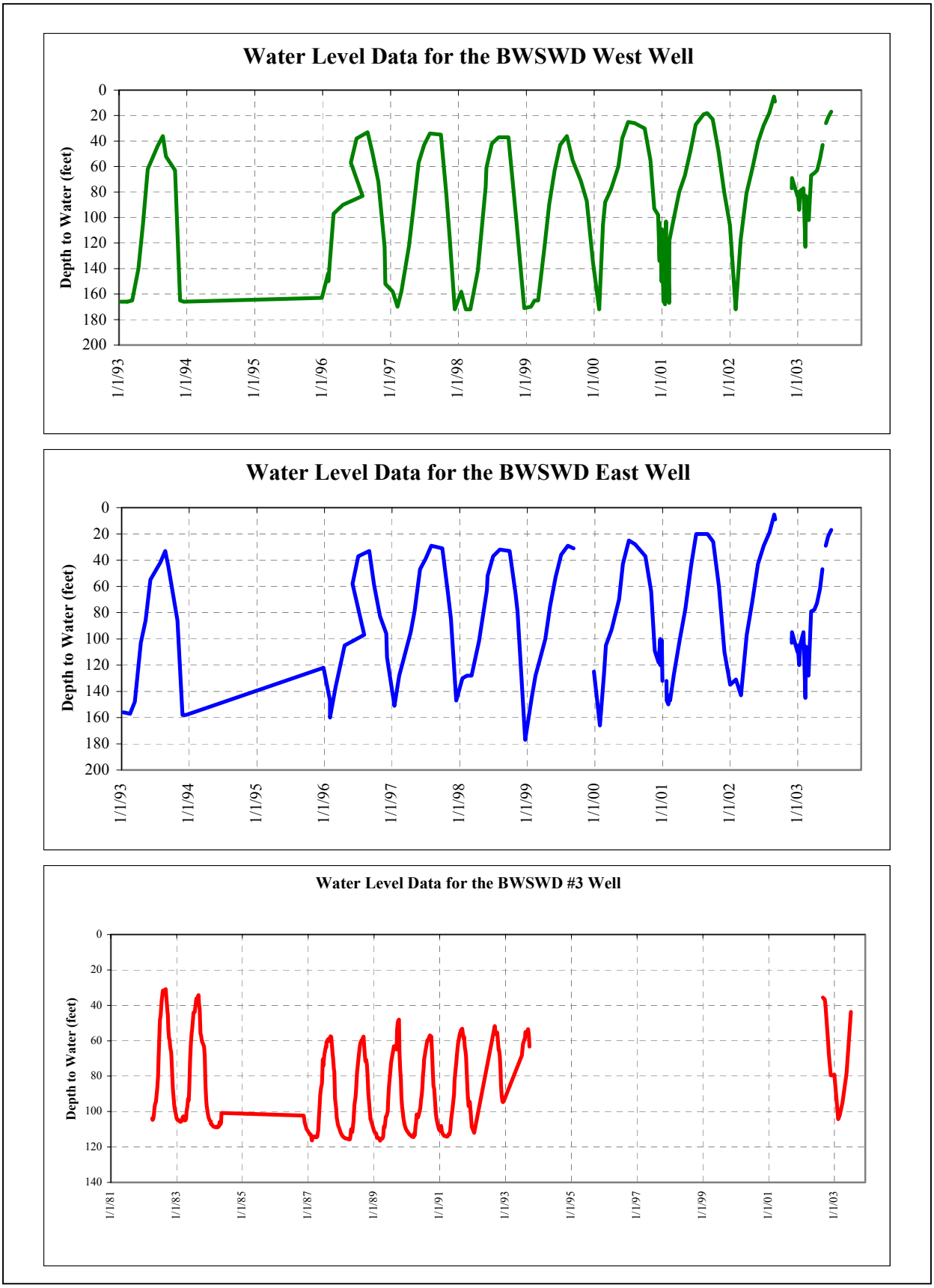

Figure 2. Water levels in the BWSWD East, West, and #3 wells.

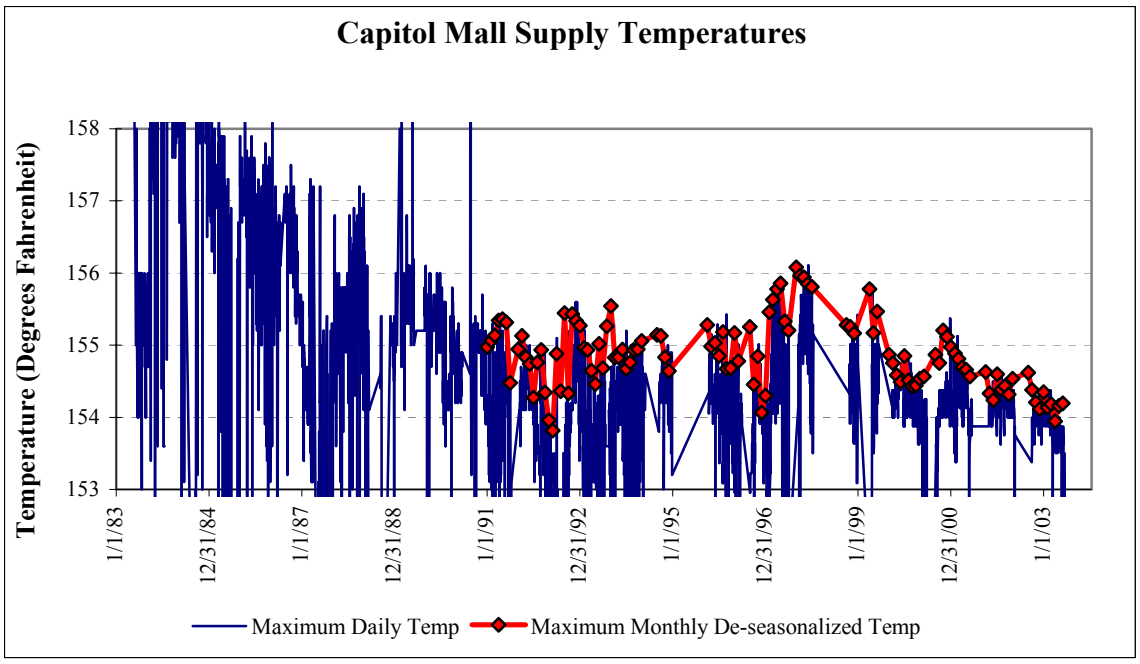

Figure 3. Water supply temperatures for the Capitol Mall system.

Monitoring data for the Kanta well after March 17 were discarded because of an equipment problem. Water levels at the Quarry View well were submitted in hardcopy. Data were recorded monthly during the first half of 2003. The maximum water level, which occurred in April, 2003, was 1.07 feet higher than the maximum peak in April 2002.

1.3.4. Veterans Administration (Production, Injection and Test Injection)

Monitoring data for Veterans Administration were submitted on monthly hand-recorded log sheets for the production and injection wells by Larry Post. The data include totalizer readings, discharges, supply and return temperatures, water levels, pump information and injection line pressures. According the Table 4 of Exhibit 1 of the Signed Order, the VA is requested to submit weekly data for two six-week time periods in the year, and specific data for the injection and test injection well, in addition to the production well data. Water level/pressure data for the test injection well, flow rates for the injection well, and the February data sheet for the production well were not received by IDWR. There was only one entry in the March 1- 14 time period for the production well.

Water levels were graphed when the pump was on "low" speed. The data for 2002 and 2003 appear to be questionable because a manual measurement in the summer of 2002 was about 80 feet higher than the low speed pumping water levels (Figure 6).

1.3.5. Old Penitentiary Well

Water level data for the Old Penitentiary well were submitted by Sharon Murray (Idaho Department of Lands, in a Word® file. Water levels are collected on a monthly basis. Water levels fluctuated less than 1.5 feet in the first half of 2003 (Figure 7).

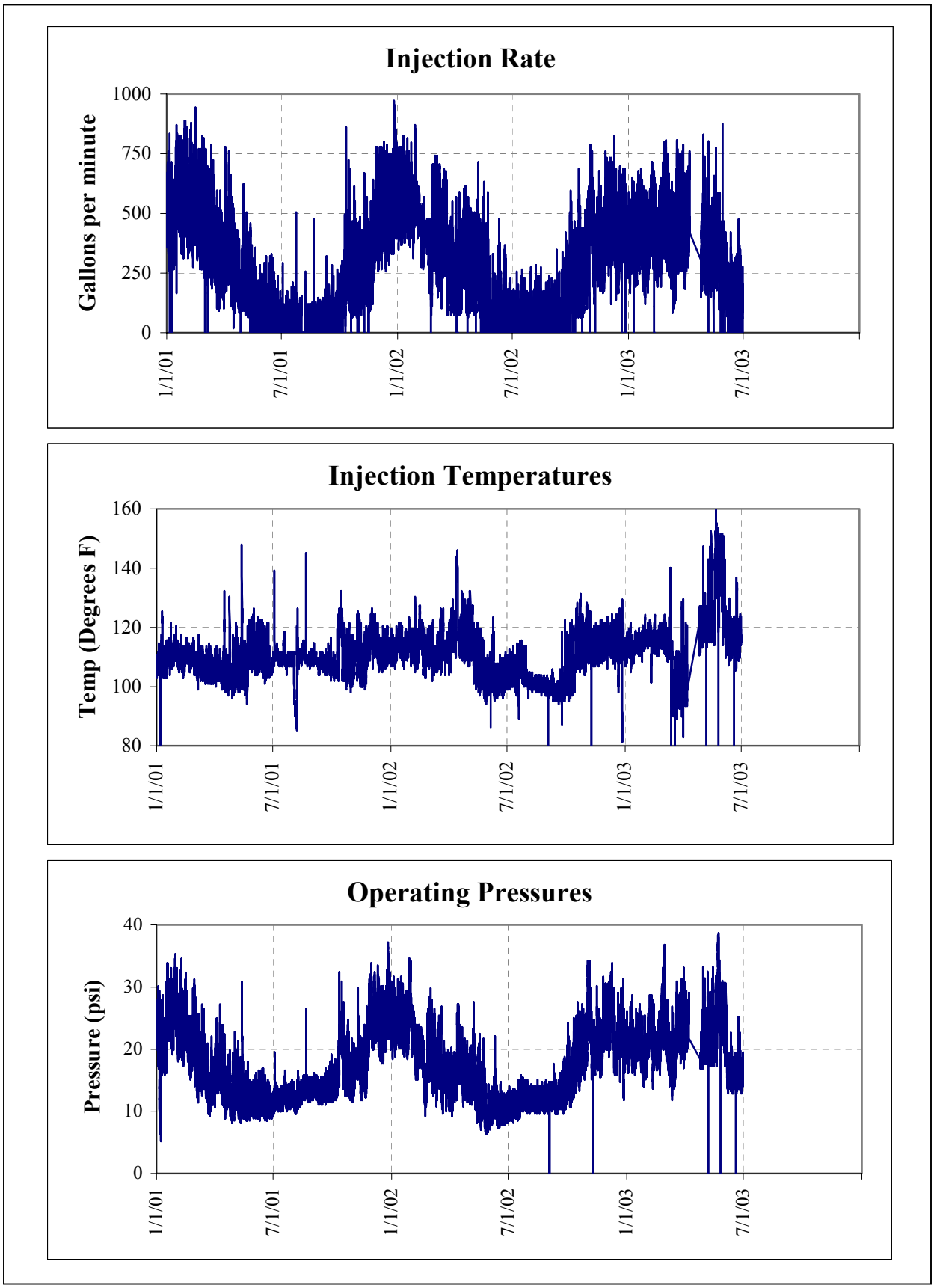

Figure 4. Monitoring data for the City of Boise's injection well.

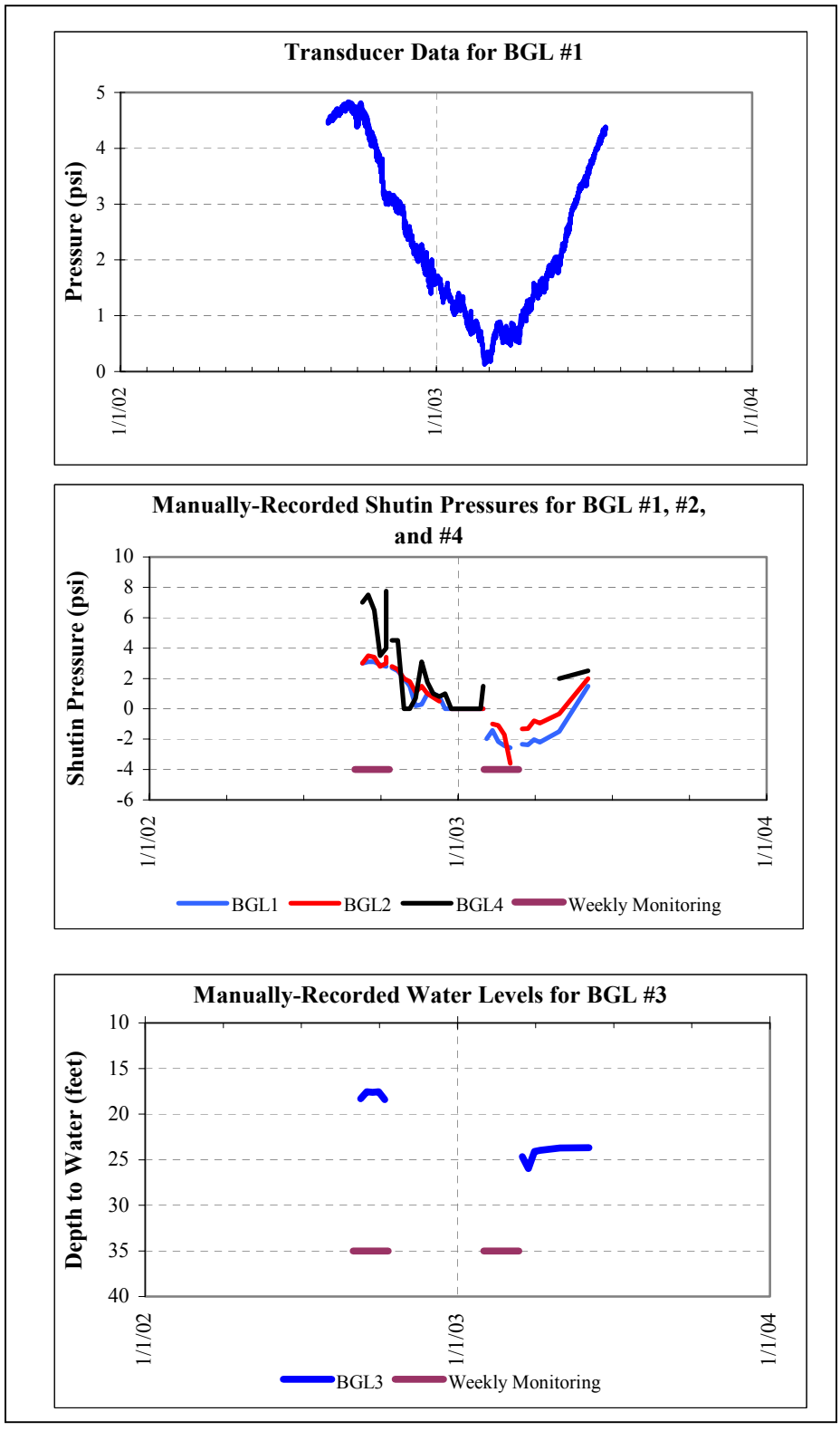

Figure 5. Monitoring data for the City of Boise's BGL #1, #2, #3, and #4.

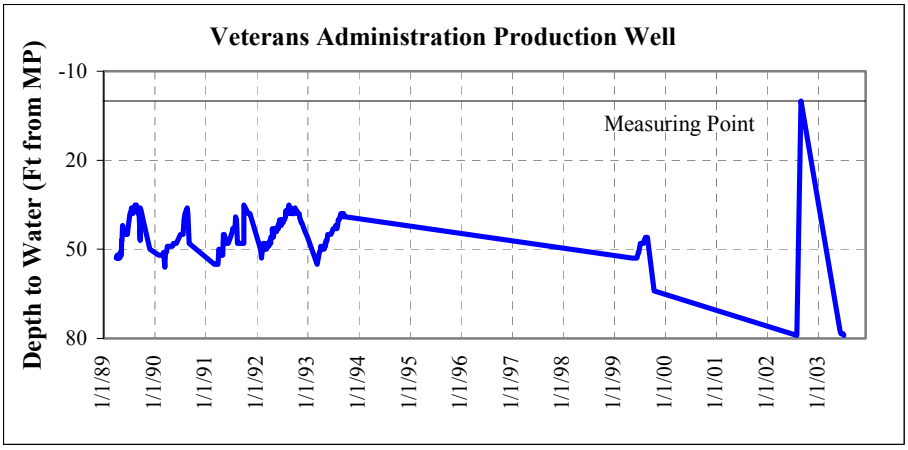

Figure 6. Water levels in the VA Production well when the pump was on the low setting (The highest reading was taken during the mass measurement in August, 2002).

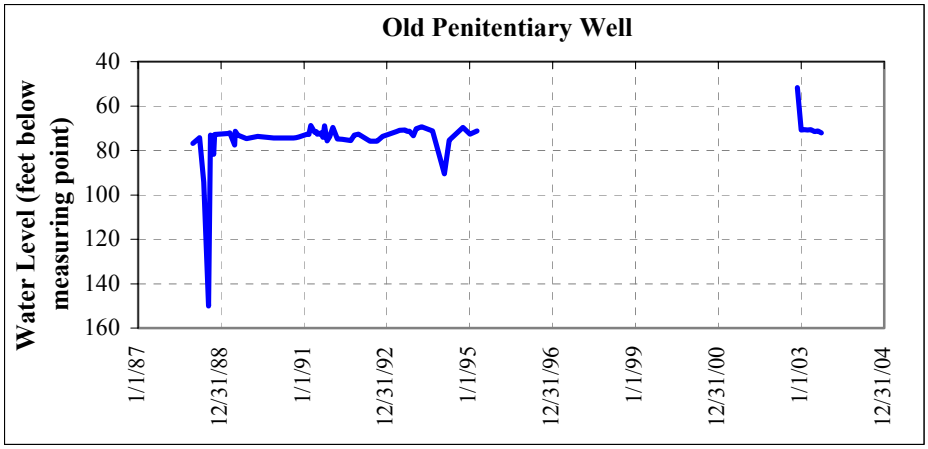

Figure 7. Water levels in the Old Penitentiary well.

1.3.6. Harris Ranch, West and East Wells

Water level and temperature data for the two Harris Ranch wells were submitted in an Excel® file by Steven Hannula (ERO Resources). Water levels and water temperatures were captured at four-hour intervals by a data logger for the West well. Manual water level measurements were recorded for both the East and West wells on a weekly basis (Figure 8).

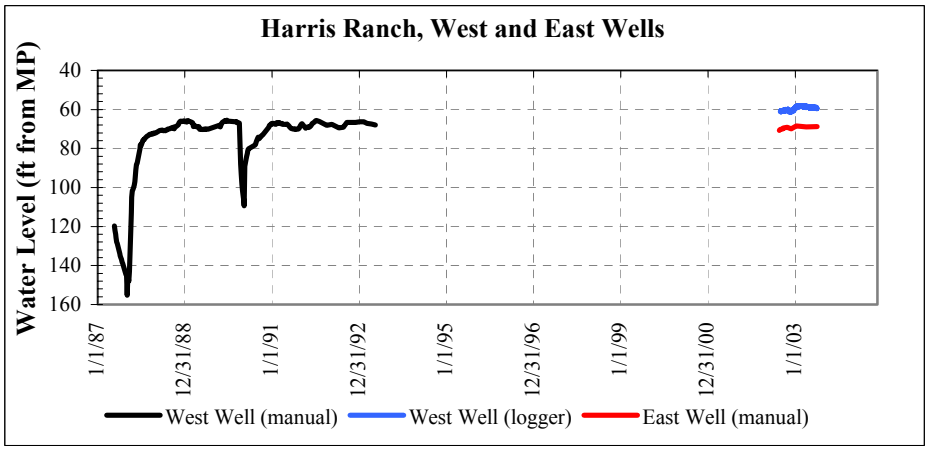

Figure 8. Water levels in the Harris Ranch West and East wells.

2. STEWART GULCH GROUND WATER DISTRICT 63-S

2.1. Production

Table 2 shows production totals for the Stewart Gulch Water District 63-S wells for the first six months of 2003.

Table 2. Production from Stewart Gulch Water District 63-S geothermal wells in the first six months of 2003.

Well	Production (gallons)
Flora Company Tiegs (Triangle)	0
Flora Company Silkey (Shed)	21,927,916
Flora Company House (Office)	2,041,427
Edwards Greenhouse	48,417,000
Terteling Ranch Windsock	49,129,223
Terteling Ranch Pool	11,782,209
Terteling Ranch Motorcycle Club	0
Quail Hollow Upper	2,508,525
Quail Hollow Lower	86,325
Total	**135,892,625**

2.2. Individual Data Summaries

2.2.1. Edwards Greenhouse

Monitoring data for the Edwards Greenhouse were submitted in hardcopy log sheets by Garnette Monnie. Data were collected at approximately once-a-week intervals. Shut-in pressures have declined slightly since the fall of 2001, but are still considerably higher than the readings in the early to mid 1990s (Figure 9). In addition to these data, the Water Master for Ground Water District 63-S began collecting monthly readings in June, 2003.

2.2.2. Flora Company Tiegs, Silkey, and House wells

Monitoring data for the Flora Company Tiegs, Silkey, and House wells were submitted in Excel® files by Ed Squires (HydroLogic, Inc.). Shut-in pressure data were recorded manually for all three wells on an approximately once-a-month frequency. Monitoring data were also collected using data loggers on the Tiegs and Silkey wells at a frequency of once every four hours for Tiegs and once every hour for Silkey. Shut-in pressures were slightly lower in the first half of 2003 than in 2002, and also lower than in 2001 for the Tiegs and House wells (Figure 10). In addition to these data, the Water Master for Water District 63-S began collecting monthly readings in June, 2003.

2.2.3. Terteling Ranch Windsock, Pool, Motorcycle Club wells

Monitoring data for the Terteling Ranch Windsock, Pool, and Motorcycle Club were submitted in Excel® files by Ed Squires (HydroLogic, Inc.). Manual measurements at the three wells were collected once a month. Data loggers recorded data at a frequency of one reading per hour. Water levels were lower in the Terteling wells from July 2002 to June 2003 than in preceding 12 months (Figure 11). In addition to these data, the

Water Master for Ground Water District 63-S began collecting monthly readings in June, 2003.

2.2.4. Quail Hollow

Monitoring data for January through April were submitted for the Quail Hollow Upper and Lower geothermal wells by Dave Hendrickson. Water level and totalizer measurements at the two wells were recorded monthly. In addition to these data, the Water Master for Water District 63-S began collecting monthly readings in June, 2003. Water levels in the first half of 2003 were lower than in 2002, which had usually high water levels for both the Upper and Lower wells, but were higher than the water levels in 2001 (Figure 12).

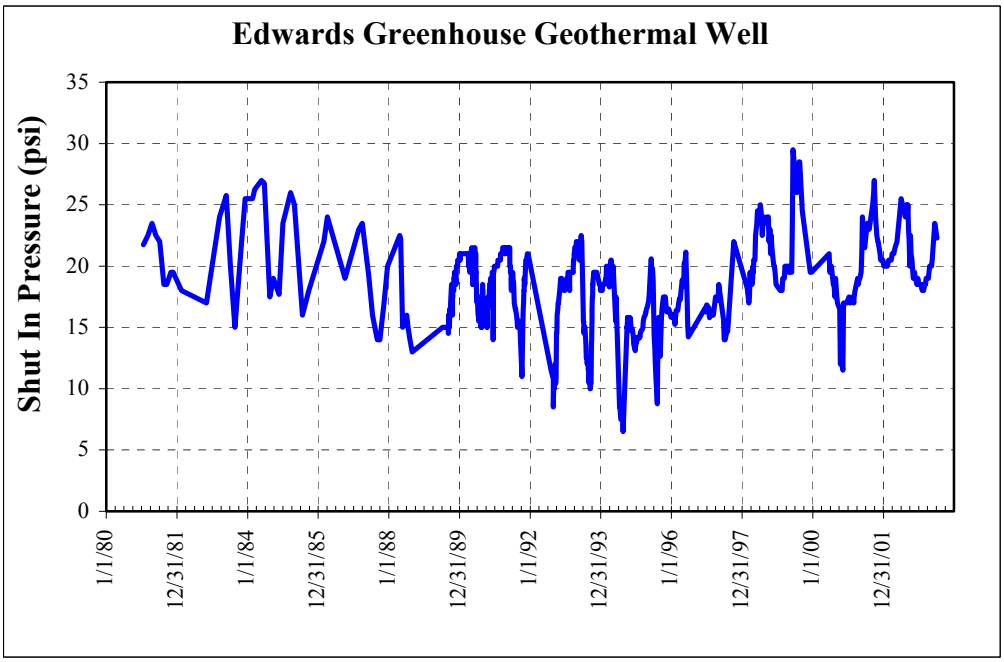

Figure 9. Shut-in pressures in the Edwards Greenhouse well.

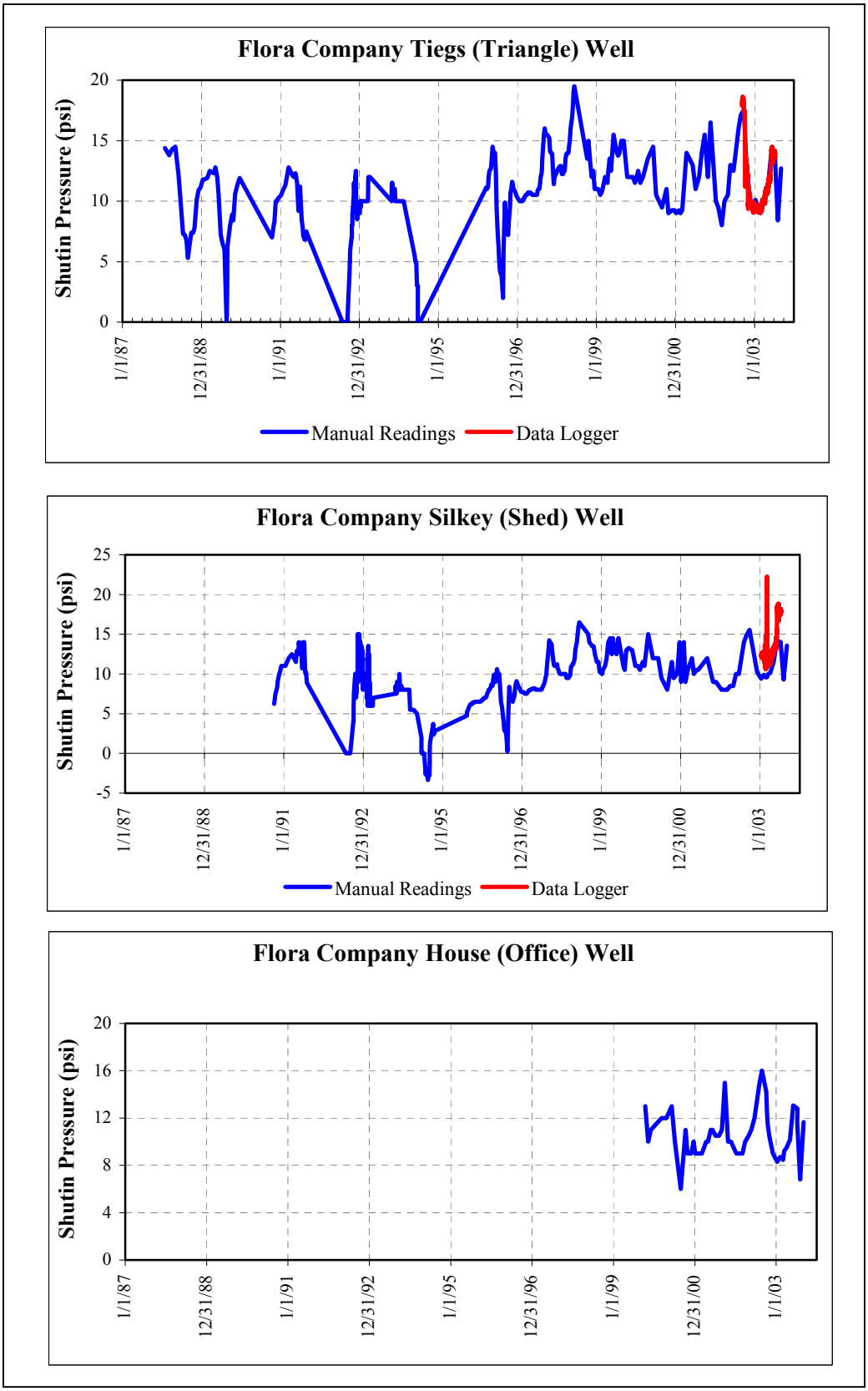

Figure 10. Shut-in pressures in the Flora Company Tiegs, Silkey, and House wells.

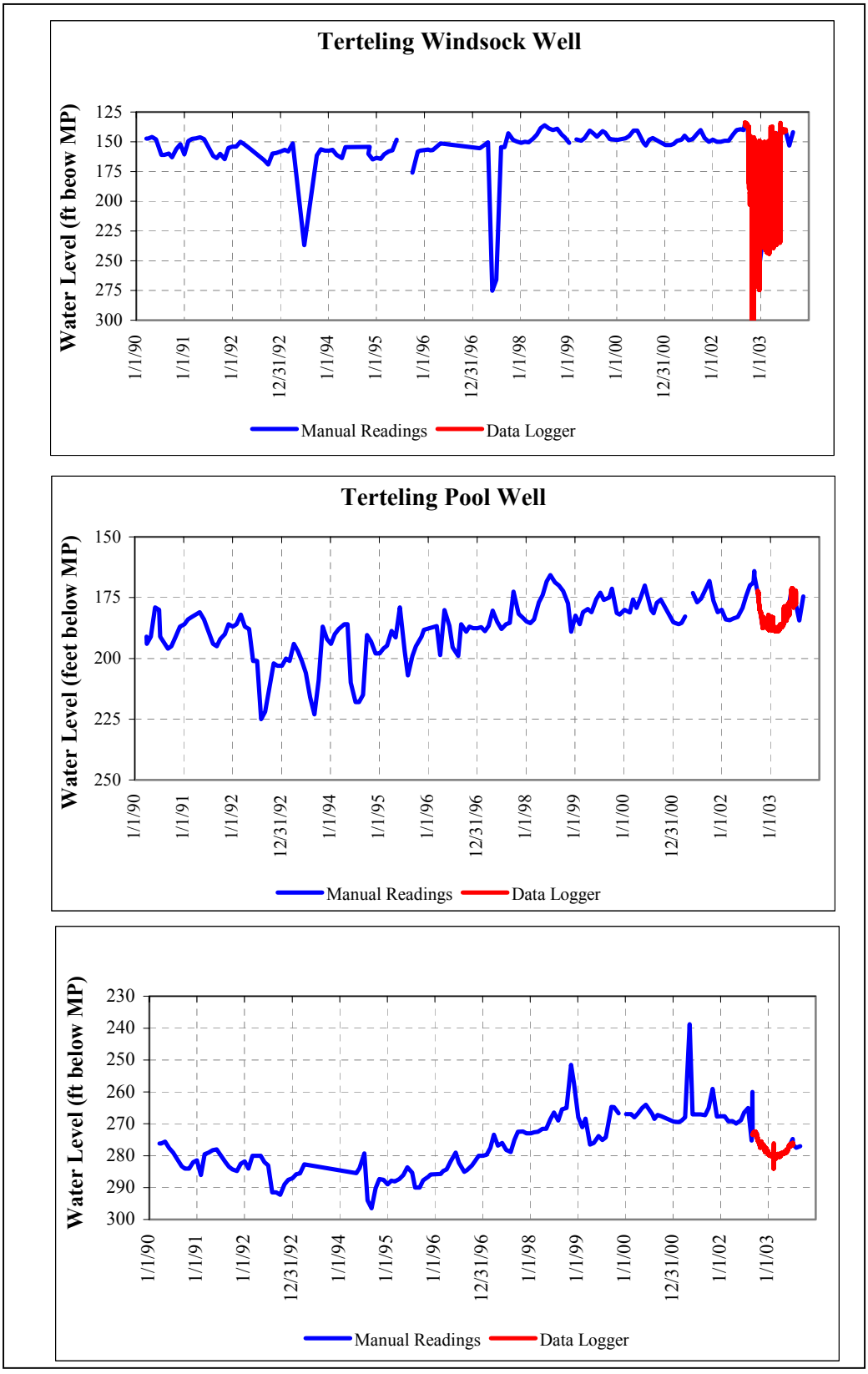

Figure 11. Water levels in the Terteling Company Windsock, Pool, and Motorcycle Club geothermal wells.

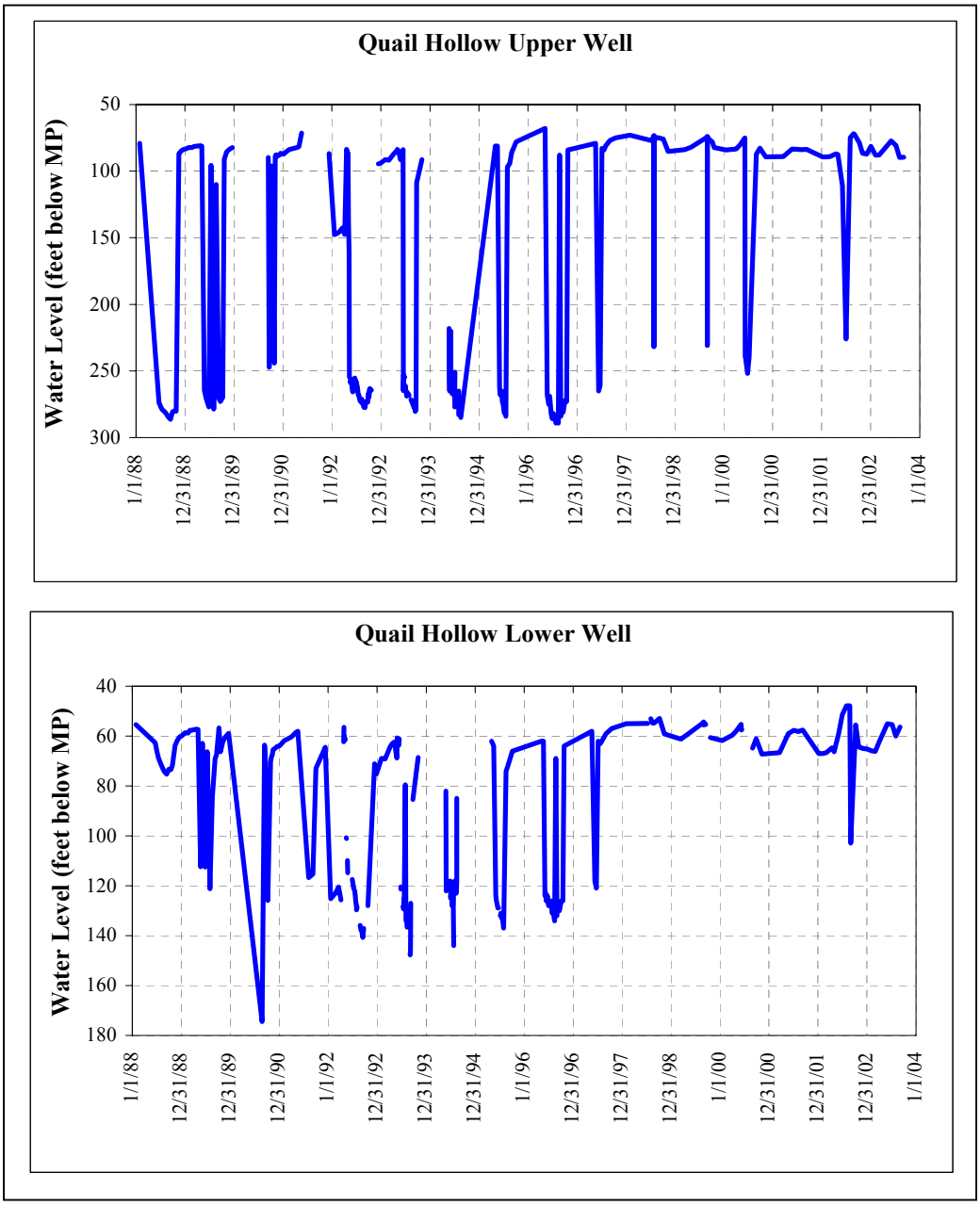

Figure 12. Water levels in the Quail Hollow Lower and Upper geothermal wells.

3. RECOMMENDATIONS

Monitoring requirements for the geothermal users in the Boise Front system are complex. Users find themselves needing to adhere to one or more of the following legal proceedings:

1. Boise Front Low Temperature Geothermal Resources Ground Water Management Area (GWMA) (June, 1987).
2. Orders requiring monitoring and record keeping for four of the geothermal users in the Boise Front Low Temperature Geothermal Resources GWMA (July, 1987).
3. Order establishing a moratorium in the Boise Front Low Temperature Geothermal Resources GWMA (June, 1988, with five-year extension orders signed in 1993 and 1998).
4. Order establishing Water District 63-S, Stewart Gulch (December, 1989).
5. Order giving the Water Master of Water District 63-S the authority to administer ground water in the district under the terms of the Silky v. Tiegs decree, and to fill senior water rights if artesian pressure is not sufficient (September 1990).
6. Stipulated Agreement in the matter of petition for order authorizing additional use for the City of Boise (July, 2002).
7. Order accepting settlement in the matter of petition for order authorizing additional use for the City of Boise (September, 2002).

Numbers 2, 4, and 6 contain language regarding geothermal monitoring.

- In Number 2, the Boise Warm Springs Water District, City of Boise, State of Idaho Capitol Mall, and Veterans Administration were required to collect: 1) continuous withdrawal rate and withdrawal amounts, 2) continuous casing pressure and/or drawdown measurements on production and injection wells, and 3) temperatures of withdrawn and injected fluids on a daily basis.

- In Number 4, the owners of wells in Water District 63-S were required to "install flow measuring devices and the rate of flow and volume of pressure measuring equipment acceptable to the Department for the measurement of the rate of flow and volume of water diverted from the respective wells". There was no language in the Order regarding the reporting of the data to IDWR.

- In Number 6, each party to the agreement is to "comply with the Monitoring and Reporting Plan attached hereto as Exhibit 1…". Parties to the agreement include: Perkins Coie LLP (representing the City of Boise), Moore Smith Buxton & Turke Chartered (representing the Boise Warm Springs Water District), Hofstetter Law Office (representing the Edwards Family LLC), State of Idaho Department of Administration, State of Idaho Department of Lands, and Ringert Clark (representing the Terteling Company, Inc.). Tables 1-3 provide the details for monitoring the wells owned by the above parties. Table 4 lists Non-Party wells which includes the following owners: USGS, VA, Quail Hollow, and Harris Ranch.

Based on my interpretations of the orders, the following recommendations are made for the collection and reporting of monitoring data:

1. **Boise Warm Springs Water District.**
    a. Data are being recorded on a daily basis on log sheets. Data loggers would allow data to be collected in a more "continuous" fashion as required by the order of 1987.
    b. Check the East Well Signet and Sparling flowmeters for accuracy.
    c. Was West Well Signet checked for accuracy when it was installed in 2002? If not, can it be checked?
    d. It would be helpful to have the daily data entered into a spreadsheet and submitted electronically. The entries that I would like to have included in a spreadsheet are: Date, Time, Water Level, Rate, Totalizer Reading, and Temperature. IDWR could provide a spreadsheet template.
2. **Capitol Mall System.**
    a. Check the temperature sensor that measures supply temperatures for accuracy.
3. **City of Boise.**
    a. Re-establish data logger monitoring at the Kanta well.
    b. Collect monitoring data weekly at the BGL #2, #3, and #4 during the two time intervals designated in Table 2 of Exhibit 1.
    c. Check temperature sensor that measures return temperature at the injection well for accuracy.
4. **Veterans Administration (**Non-Party).
    a. Data are being recorded on an average of about 10 readings per month on log sheets. Data loggers would allow more "continuous" collection of monitoring data as required by the order of 1987.
    b. Determine if the air line on the production well is working properly for collecting water level data. Perhaps the well can be shut down for a short time, and static water levels can be taken by using a steel tape and an electric tape, and with the airline procedure that is currently used.
    c. Collect water levels in the injection and test injection wells on a weekly basis.
    d. It would be helpful to have the log sheet data entered into a spreadsheet and submitted electronically. IDWR could provide a spreadsheet template.
5. **Flora Company.**
    a. Determine the reason that the manual readings and the data logger readings on the Shed well are not in agreement.
6. **Edwards Greenhouse**
    a. Can the daily log data be entered into a spreadsheet and submitted electronically? IDWR could provide a spreadsheet template.
7. **Terteling Ranch.**
    a. Record water temperature at the Pool and Windsock wells.
8. **Quail Hollow** (Non-Party).
    a. Since the two wells are "Non-Party" according to Table 4 of Exhibit 1, Mr. Hendrickson believes that Quail Hollow is not required to submit monitoring data. A discussion of the matter with John Homan (attorney at IDWR) and a review of the order for the Ground Water District 63-S monitoring requirements leads me to agree with Mr. Hendrickson's conclusions. As such, all monitoring data (i.e., water levels, instantaneous flows, and totalizer readings) will be collected on a monthly basis by the

Water Master of Water District 63-S, as per the plan adopted by the District. Weekly data collections for the two six-week time periods in Table 4 of Exhibit 1 will not be collected since that frequency is beyond the duties defined for the Water Master of Water District 63-S.

9. According to the Stipulated Agreement of July 2002, IDWR is to visit each well listed in Tables 1-4 of Exhibit 1 annually, with the goal of checking the accuracy of monitoring gages and performing calibrations. The goal is to accomplish this task in October or November, 2003.